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ASSIMILATION OF SOLIDS DURING ASCENT OF MAGMAS FROM THE BARTOY FIELD OF THE BAIKAL REGION, SIBERIA Johnson R. Haas[1], Larry A. Haskin[1], James Luhr[2], and Sergei Rasskazov[3], 1 Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130; 2 Dept. of Mineral Sciences, Smithsonian Institution, Washington D. C., 20560; 3 Institute of the Earth's Crust, Irkutsk, Russia.

Most investigators ascribe mare basalt magma genesis to partial melting at depths of ~130 - >400 km [e.g., 1-4] within the cumulate pile deposited from a lunar magma ocean. Mare basalts share with mid-ocean ridge basalts the characteristic of relative depletion in LREE and other incompatible trace elements that arises from melting within "used" mantle, from which crust-forming elements have already been separated. Some mare basalt types do not show the classical, La-Nd depleted mare basalt REE distributions, however, and some types are isotopically heterogeneous. These differences have been ascribed to assimilation, mainly AFC-style [5], of KREEPy highland material overlying the source region [e.g., 6-9 and references therein]. Might such assimilation occur during magma ascent through the KREEPy material? To gain information from a terrestrial setting on possible assimilation during ascent, we have studied a suite of Quaternary nepheline-hawaiites and nepheline-mugearites from the Bartoy cinder cone complex of the Baikal Rift, Siberia. The Bartoy magmas originated from >80 km deep, and erupted through thick Archean crust [10]. We find evidence for assimilation of ~31 wt% xenocrysts of garnet, aluminous clinopyroxene, kaersutite, and olivine, all presumably from the basalt source region, but no appreciable assimilation of overlying crust, consistent with isotopic constraints [11]. Magmatic superheat made available by rapid ascent and decompression accounts adequately for the energy of assimilation; no accompanying fractional crystallization is required or evident.

Compositional models for mare basalt genesis from magma ocean cumulates account intriguingly well for gross features of major element composition and REE distribution, but usually fall short of quantitative descriptions of basalts of a given type or from a given region, and particularly fail to account for high-Al (HA) basalts and very high-K (VHK) basalts from Apollo 14 [e.g., 12], and type B2 basalts from Apollo 17 [13]. Assimilation of KREEPy material has been proposed to account for the differences.

The deep source region of the Bartoy magmas (22-25 kb [10]), coupled with the overlying thick, Archean crust, facilitate detection of crustal assimilation within the ascended, mantle-derived magmas. Unlike lunar lavas, the Bartoy suite contains abundant mafic xenoliths, cm-sized megacrysts, and fine- to coarse-grained xenocrysts. Principal xenocrystic minerals are garnet, clinopyroxene, and kaersutite [10]. Basalt samples analyzed were aphanitic fragments free of obvious macroscopic contamination by xenoliths, xenocrysts, and megacrysts.

Chondrite-normalized REE distributions are shown in Fig. 1. The lavas are notable for their systematic decrease in HREE concentrations with increasing LREE concentrations, with all REE patterns "rotating" about the position of Dy-Ho on the diagram. These variations in REE concentration preclude low-pressure fractionation, which would produce a stack of roughly parallel REE patterns. Petrogenesis involving garnet is indicated by these crossing REE patterns.

The compositions of the lavas are accounted for precisely by a chemical mixing model as mixtures of BK-134 (the most evolved lava) and megacrystic garnet, clinopyroxene, kaersutite, and minor olivine, all of constant compositions. The mixing results are so precise that, although the lava compositions vary substantially (Max/Min of 1.9 for MgO, 2.1 for Sc, 1.3 for Co, 1.4-1.5 for LREE and other incompatible elements, and 1.6 for HREE), small errors in mixing-model fits are significantly independent of the estimated proportions of BK-134 and xenocrysts in the mixtures; i.e., constant composition of mixing end members is required by the precise fits. Analyzed xenocrysts show little compositional variation. Concentration ranges of major elements are inconsistent with fractional crystallization of high-pressure, equilibrium clinopyroxene and garnet. Observed concentration ranges of compatible trace elements are too large to be consistent with the extents of partial melting of a single source estimated from concentration ranges of incompatible trace elements (e.g., Fig. 2).

Petrographic observations of the Bartoy lavas support the assimilation model. Small xenocrysts are absent. Larger garnet xenocrysts are corroded, suggesting that assimilation occurred for as long as excess heat was available. Larger clinopyroxene xenocrysts are corroded, but subsequently armored with augite of low-pressure composition, suggesting that assimilation occurred until clinopyroxene reappeared on the liquidus during or just prior to eruption. Olivine occurs as two populations -- compositions of Fo85, interpreted to be xenocrysts, and compositions as low as Fo60, interpreted to be phenocrysts. Kaersutite appears as xenocrysts. We estimate the quantity of heat available from pressure release to be roughly 260 J/g, enough to supply the ~230 J/g needed for assimilation of ~30 wt% of xenocrystic material.

The compositions of the garnet, clinopyroxene, and olivine xenocrysts are those expected for high-pressure equilibrium with the most evolved lava, BK-134 [14], suggesting that the xenocrysts might have been part of the source system. The ferroan, alkalic composition of BK-134 constrains the mineralogy of its source-rock to be essentially olivine- and orthopyroxene-free. The source rock was probably a metasomatized garnet clinopyroxenite. The isotopic data indicate that no appreciable assimilation of Archean crust could have occurred [11]. Thus, despite apparent excess heat, portions of the ascending magmas in the crust must have chilled against their conduits, rather than removing and assimilating ancient crust from them. This suggests that magmas rising rapidly from depth within the Moon could also have avoided significant assimilation at higher levels, consistent with conclusions of [15] for ascending magma. Some physical arrangement other than mere ascent through a KREEPy layer may be required if significant incorporation of KREEPy material occurred.

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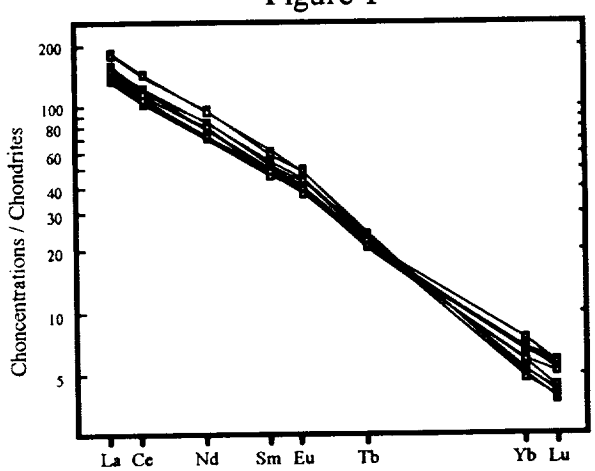
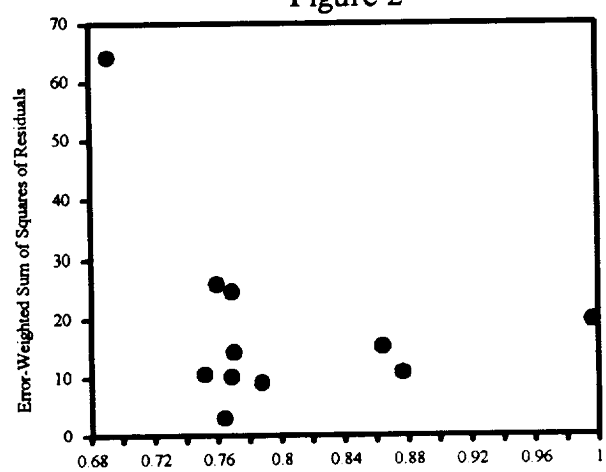
Figure 1



REE ATOMIC NUMBER

Figure 2



BK-134 Proportions

[1] Walker *et al.* (1975) *Geochim. Cosmochim. Acta* 39, 1219-1235 [2] Binder (1982) *Proc. Lunar Planet. Sci. Conf.* 13, A37-A53. [3] Hughes *et al.* (1989) *Proc. Lunar Planet. Sci. Conf.* 19, 175-188 [4] Neal and Taylor (1992) Apollo 17 Workshop, LPI [5] DePaulo (1981) *Earth Planet. Sci. Lett.* 53, 189-202. [6] Binder (1985) *Proc. Lunar Planet. Sci. Conf.* 16, D19-D30 [7] Shervais *et al.* (1985) *Proc. Lunar Planet. Sci. Conf.* 16, D3-D18 [8] *Proc. Lunar Planet. Sci. Conf.* 18, 139-153. [9] Neal & Taylor, (1990) *Proc. Lunar Planet. Sci. Conf.* 20, 101-108. [10] Rasskazov *et al.* (1990) Volc. Seis. 11, 337-353. [11] Luhr *et al.* (1992) EOS, Trans. Am. Geophys. Un. 72, 266. [12] Neal *et al.* (1989) *Proc. Lunar Planet. Sci. Conf.* 19, 147-161 [13] Paces et al. (1991) *Geochim. Cosmochim. Acta* 55, 2025-2043 [14] Kushiro *et al.* (1972) *Earth Planet. Sci. Lett.* 14, 19-25. [15] Irving (1980) *Am. J. Sci.* 280-A, 389-426.